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Effects of doping site and concentration on upconversion luminescence of Er^{3+} doped $Ba(Mg_{1/3}Nb_{2/3})O_3$

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Upconversion (UC) luminescence of rare earth ions doped perovskite-structure materials has been investigated extensively in recent years due to their widespread applications in solar battery, biomedical sensing and optical lasers [1-3]. The complex perovskite $Ba(Mg_{1/3}Nb_{2/3})O_3$ (BMN) compounds is a peculiar microwave dielectric material and it has different site symmetries of Ba-site (C_{3v} and D_{3d}) [4]. Its high structural diversity and tolerance provide adjustable crystal site points for rare-earth ions. But there is very limited knowledge about the influence of the site symmetry of Er^{3+} doped BMN on its photoluminescence (PL) properties.

In this work, BMN perovskite upconversion (UC) phosphors doped with 1.0, 2.0, 3.0, 4.0, 5.0 mol.% of Er^{3+} were synthesized by a well-designed sol-gel method. The prepared powders were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), ultraviolet visible spectrophotometer and photoluminescence (PL) spectra. SEM results demonstrate that BMN: Er phosphors are uniform spherical nanostructures with a mean diameter of 20 nm. Structural analysis results show that the powder possesses hexagonal structure and Er^{3+} ions enter the Ba-sites of BMN crystal structure. Under the excitation of 980 nm infrared light, BMN: Er^{3+} show bright green emission near 524 nm and 548 nm generated by the $^2H_{11/2}/^4S_{3/2}\rightarrow{}^4I_{15/2}$ transition, relatively weak red emission is observed near 662 nm due to the $^4F_{9/2}\rightarrow{}^4I_{15/2}$ transition. When the doping concentration of Er increases, the intensity of the green light present earlier increase and later decrease trend whereas the red light almost has no change. According to the analysis of Judd-Ofelt and hypersensitive transition theory, it is related to the symmetry of doping site. The results demonstrate that the site symmetry plays an important role in the intensity of PL. Different green to red ratio is attributed to the local symmetry influence on the emission bands. Hence, it is reasonable to conjecture that characteristics of luminescence (i.e. green to red ratio) can be modulated by adjusting doping site and concentration.

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